EA Engineering, Science, and Technology, Inc.

225 Schilling Circle
Hunt Valley, MD 21031
Telephone: 410-584-7000
FAX: 410-771-1625
www.eaest.com

16 June 2014

TECHNICAL MEMORANDUM

TO: Andrew Fan (EPA)
Barbara Brown (MDE)
Madi Novak (Maul Foster & Alongi, Inc.)
Dan Silver (Sparrows Point Environmental Trust)

FROM: Samantha Saalfield, Project Geologist
Frank Barranco, Project Manager

SUBJECT: **Proposed Approach and Methods for Groundwater Sampling Sparrows Point Offshore Investigation**

This Technical Memorandum describes the proposed approach and methods for groundwater sampling in the Rod & Wire Mill and Humphrey Impoundment areas, under Task 3 of the Sparrows Point Offshore Investigation. The Sparrows Point Environmental Trust (the Trust) has contracted EA Engineering, Science, and Technology, Inc. (EA) to plan and implement groundwater sampling from existing monitoring wells in these areas of the Sparrows Point Facility adjacent to the Northwest Shoreline study area (the Phase 1 area).

Background and Objectives:

Groundwater sampling will be conducted to aid in identification of constituents of potential concern (COPCs) that may have been transported via groundwater flow to the offshore sediment and surface water in the Phase 1 area. Samples will be collected from 10 existing monitoring wells along the shoreline near the Rod & Wire Mill and Humphrey Impoundment areas. Groundwater from the Rod & Wire Mill is regularly monitored for cadmium and zinc, in conjunction with a pump and treat system; however, no data for other potential COPCs are available for groundwater from this area. The most recent groundwater sampling and analysis in the Humphrey Impoundment area occurred in 2004. Based on this, EPA and MDE determined that additional groundwater data are necessary to support identification of COPCs. The samples collected will be analyzed for volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), priority pollutant list (PPL) metals, and cyanide.

The overall objective of the groundwater sampling is to provide recent data for COPCs that are suspected to have been transported via groundwater to sediment and pore water. Risk-based criteria for surface water will be used to screen the new groundwater data, along with recent (2009-2014) data from regular groundwater sampling along the shoreline adjacent to Grey's Landfill. The COPCs identified based on screening will be incorporated into analytical list for sediment and pore water samples to be collected and analyzed under the work plan for the Sparrows Point Offshore Investigation.

The following ten existing wells have been selected for sampling, to provide data from the shallow, intermediate, and deep groundwater zones along the Phase 1 shoreline:

Well	Area	Groundwater Zone
HI08-PZM003	Humphrey Impoundment	Shallow
HI08-PZM060	Humphrey Impoundment	Deep
RW18-PZM047	Rod & Wire Mill	Deep
RW19-PZP000	Rod & Wire Mill	Shallow
RW19-PZM020	Rod & Wire Mill	Intermediate
RW19-PZM050	Rod & Wire Mill	Deep
RW20-PZP000	Rod & Wire Mill	Shallow
RW20-PZM020	Rod & Wire Mill	Intermediate
TS04-PDM004	Rod & Wire Mill	Shallow
TS04-PZM023	Rod & Wire Mill	Intermediate

Approximate well locations are illustrated on Figure 1, and additional details regarding these wells are provided in Table 1.

Activities associated with the groundwater sampling effort will include 1) a well survey to assess the condition of the existing monitoring wells, 2) re-development of the wells selected for sampling, to improve the representativeness of the samples collected, 3) collection of groundwater samples using low-flow methods, 4) analysis of groundwater samples for likely COPCs, 5) validation of the groundwater data, 6) investigation-derived waste (IDW) disposal, and 7) reporting.

Monitoring Well Survey:

The integrity of the wells selected for sampling will be assessed through visual observations. The cap on each well will be removed, and a water level indicator will be used to measure the depth of the well and assess whether silt has accumulated at the bottom of the well. A Well Integrity Field Form (Attachment A) will be completed for each well. The latitude and longitude of each well will be measured using World Geodetic System (WGS) 1984 datum with a hand-held global positioning system unit. A photo of each well will be taken for inclusion on the form, with visual indication of the well number included within the photo (e.g., on a piece of paper held up in front of the well).

If any of the wells selected for sampling are found to be unavailable for sampling, the field team will assess alternative nearby wells for usability and will consult with EPA and MDE regarding potential sampling of alternative wells. It is expected that the wells at the Rod and Wire Mill will be in usable condition, as they are sampled semiannually in conjunction with the interim remedial action in that area. If any of these wells are found to be unsuitable for sampling, well RW21-PZM023 (located approximately 250 feet south of the TS04 well cluster, Figure 1) will be assessed as an alternative well. The condition of the HI08 well cluster is unknown; if the condition of either of these wells is found to be unsuitable, wells from the HI01 cluster (located approximately 500 feet north, Figure 1) will be assessed as alternative locations for sampling.

Monitoring Well Development:

Wells to be sampled will be re-developed in accordance with the standard operating procedure (SOP) included in Attachment B, to maximize the representativeness of the samples collected. Although the wells in the Rod & Wire Mill are sampled semiannually, Russ Becker of Sparrows Point, LLC has indicated that redevelopment of these wells would be beneficial. Two well development techniques, over-pumping and surging, will be employed in tandem. Over-pumping is simply pumping the well at a rate higher than recharge. Surging is the operation of a plunger up and down within the well casing similar to a piston in a cylinder. Alternating surging and pumping will continue until three well volumes have been removed. If, at this point, if the turbidity is higher than 10 nephelometric turbidity units (NTUs), then pumping without surging will be conducted until three consecutive turbidity measurements below 10 NTU are collected.

Collection of Groundwater Samples:

Groundwater samples will be collected using low-flow methods, consistent with the attached SOP (Attachment B). The well will be purged at 0.2-0.5 L/min and water quality indicator parameters (turbidity, temperature, specific conductance, oxidation-reduction potential, dissolved oxygen, and pH) will be recorded every 3-5 minutes (or as appropriate) and recorded on the purge form. Purging will continue until three consecutive measurements indicate 1) turbidity less than 10 NTUs and 2) less than approximately 10 percent variability in the other parameters. If necessary, the flow rate may be decreased to promote stabilization of these parameters. Purge water will be collected in 55-gallon drums for appropriate disposal. Dedicated tubing will be used for purging and sampling of each well, and any non-dedicated equipment in contact with groundwater will be decontaminated between wells, in accordance with the SOP (Attachment B). The depth to water in each well will be measured prior to purging, during purging, and after sampling. The total well depth will also be measured and recorded.

Samples will be collected in clean containers (Table 2) obtained from the laboratory, and labelled with the following information:

- Well ID
- Date and time of collection
- Name of sampler
- Sample preservative(s)

One duplicate sample will be collected, and a trip blank will be included in each cooler containing bottles for VOC analysis.

Samples and QC samples will be stored in an ice-filled cooler until the end of each sampling day. Samples will be packaged in bubble wrap, placed in an ice-filled cooler (or cooler with blue ice), and shipped via overnight delivery to TestAmerica–Pittsburgh in Pittsburgh, Pennsylvania. Bubble wrap will be used to line the bottom and sides of the sample cooler and fill voids where needed to cushion the sample containers during transportation. Cooler(s) will be sealed with packing tape and custody seals, and a completed chain-of-custody record representing the packaged samples will be taped to the inside of the cooler lid.

Samples will be sent directly to the following address:

TestAmerica–Pittsburgh
301 Alpha Dr.
RIDC Park
Pittsburgh, PA. 15238
(412) 963-7058
Attn: Sample Receiving

Groundwater Analysis:

TestAmerica will analyze the groundwater samples for the following:

- VOCs by EPA Method 8260C
- Low-level SVOCs (including polycyclic aromatic hydrocarbons) by EPA Method 8270D
- Total PPL metals by EPA Method 6020A
- Mercury by EPA Method 7470A
- Cyanide by EPA Method 9014.

Where possible, the analytical methods chosen have sensitivity sufficient to allow screening of the groundwater data against risk-based criteria for surface water. Analytical detection limits for these methods, along with the screening values to be used in identification of COPCs, are provided in Table 3.

Groundwater Data Validation:

Data will be validated by a third-party validator to ensure that the data meets the requirements of the project. Validation will be performed at 80 percent Level III and 20 percent Level IV.

Investigation-Derived Waste Management:

The primary IDW from the groundwater sampling will consist of development water, purge water, and decontamination fluids. This IDW will be drummed, and the results of the groundwater sampling will be used to characterize the water for disposal, either by the site owner or the Trust. Solid IDW (e.g., personal protective equipment, paper towels, etc.) will be bagged and disposed as municipal solid waste.

Reporting:

The principal objective of the groundwater sampling is to support identification of COPCs for analysis of sediment and pore water samples collected under Task 4. The analytical results from this groundwater sampling event will be presented in an appendix to the Phase 1 Offshore Investigation Work Plan developed under Task 3. The results of screening of the data will be presented in the body of the Work Plan. Note that validated data may not be available for inclusion in this work plan, due to project schedule constraints; however, validation is not expected to have a significant impact on the results of screening and COPC identification.

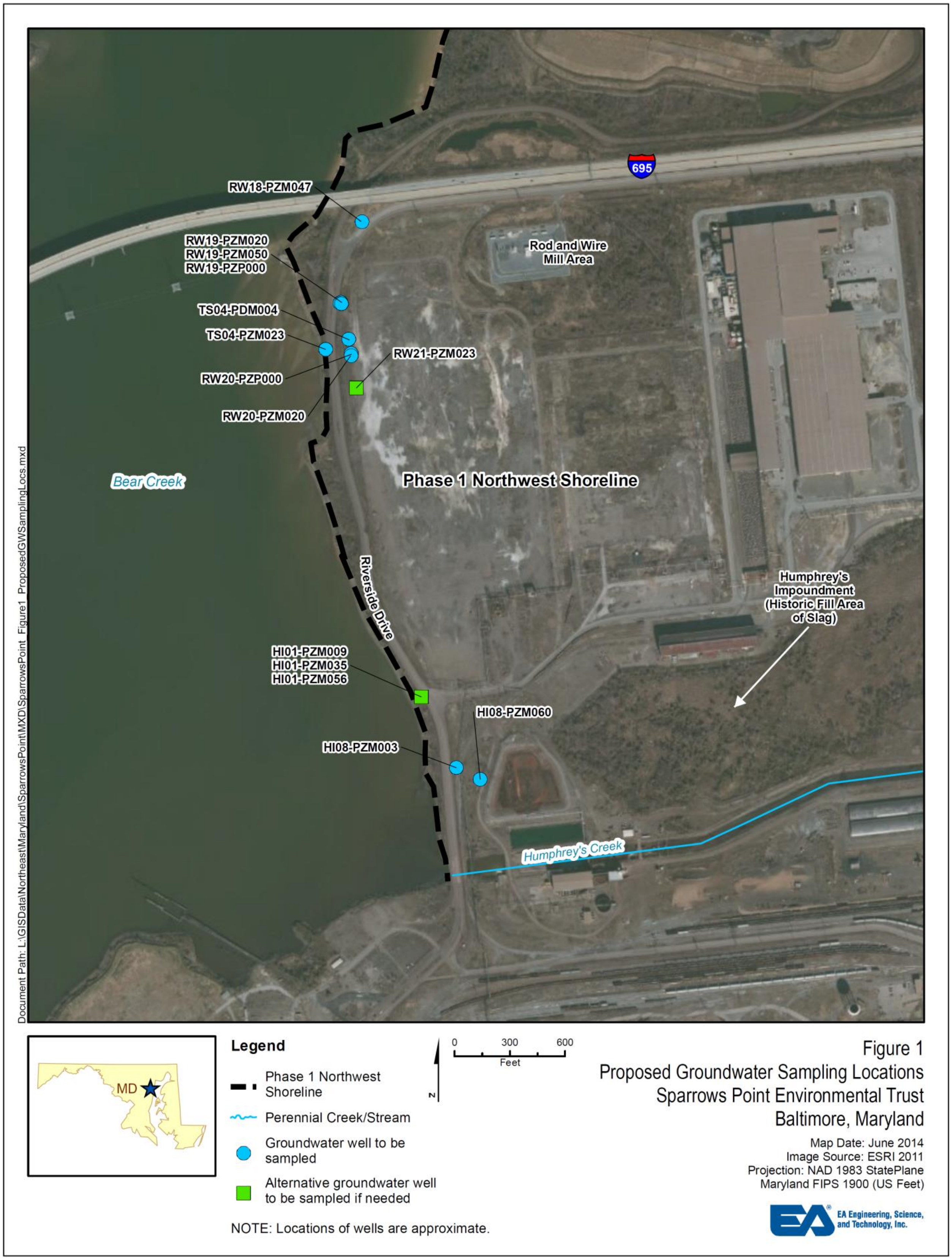

Figure 1
Proposed Groundwater Sampling Locations
Sparrows Point Environmental Trust
Baltimore, Maryland

Table 1. Well Characteristics

Well	Easting	Northing	Groundwater Zone	Top of Casing Elevation (ft)	Total Depth (ft)	Date Depth to Water Measured	Depth to Water (ft)
HI08-PZM003	Not Available	Not Available	Shallow	Not Available	13 [b]	Not Available	Not Available
HI08-PZM060	1456724.554	569390.4937	Deep	13.115 [a]	70 [b]	6/2004	14.04
RW18-PZM047	1456083	572418	Deep	15.68	61.04 [c]	4/30/2013	15.31
RW19-PZP000	1455967	571981	Shallow	13.49	12 [c]	4/30/2013	9.04
RW19-PZM020	1455963	571974	Intermediate	13.49	32.09 [c]	4/30/2013	11.55
RW19-PZM050	1455970	571973	Deep	12.99	61.01 [c]	4/30/2013	12.45
RW20-PZP000	1456025	571702	Shallow	12.82	11.66 [c]	4/30/2013	4.38
RW20-PZM020	1456025	571690	Intermediate	13.47	32.00 [c]	4/30/2013	12.2
TS04-PDM004	1456011	571781	Shallow	13.71	17.90 [c]	4/30/2013	10.6
TS04-PZM023	1455885	571724	Intermediate	10.09	34.21 [c]	4/30/2013	8.95

a) Note: it is not known whether this is a TOC or ground surface elevation
b) Approximate depth based on well name
c) Depth as measured during monitoring in 2011

Table 2. Required Containers, Preservation Techniques, and Holding Times

Parameter	Volume Required	Container	Preservative	Holding Time
Volatile Organic Compounds	3x40 mL	Glass vial	HCl, Cool, 4°C	14 days
Semivolatile Organic Compounds	2x250 mL	Glass, teflon-lined cap	Cool, 4°C	7 days until extraction, 40 days after extraction
Metals (including Mercury)	250 mL	Plastic	pH <2 with HNO_3 Cool, 4°C	6 months (28 days for mercury)
Cyanide	250 mL	Plastic	pH >12 with NaOH Cool, 4°C	14 days

Table 3. Analytical Project Limits and Screening Values for Groundwater Samples

Parameter	Units	Laboratory Reporting Limit	Laboratory Method Detection Limit (a)	NRWQC Saltwater Aquatic Life CCC	NRWQC Human Health (Organism Only)	BTAG Value (c)	Screening Value (d)
PPL Volatile Organic Compounds - GC/MS (SW846 8260C)							
Acrolein	µg/L	100	5.73	3	9	0.55	3
Acrylonitrile	µg/L	50.0	6.82	--	0.25	581	0.25
Benzene	µg/L	5.00	--	--	51	110	51
Bromodichloromethane	µg/L	5.00	--	--	17	--	17
Bromoform	µg/L	5.00	--	--	140	640	140
Bromomethane	µg/L	5.00	--	--	--	120	120
2-Butanone (MEK)	µg/L	5.00	--	--	--	14,000	14,000
Carbon tetrachloride	µg/L	5.00	1.08	--	1.6	1,500	1.6
Chloroethane	µg/L	5.00	--	--	--	--	--
2-Chloroethyl vinyl ether	µg/L	10.0	--	--	--	--	--
Chloroform	µg/L	5.00	--	--	470	815	470
Chloromethane	µg/L	5.00	--	--	--	2,700	2,700
Dibromochloromethane	µg/L	5.00	--	--	13	--	13
1,2-Dichlorobenzene	µg/L	5.00	--	--	1,300	42	1,300
1,3-Dichlorobenzene	µg/L	5.00	--	--	960	28.5	960
1,4-Dichlorobenzene	µg/L	5.00	--	--	190	19.9	190
trans-1,2-Dichloroethene	µg/L	5.00	--	--	10,000	970	10,000
Dichlorodifluoromethane	µg/L	5.00	--	--	--	--	--
1,1-Dichloroethane	µg/L	5.00	--	--	--	47	47
1,2-Dichloroethane	µg/L	5.00	--	--	37	1,130	37
1,1-Dichloroethene	µg/L	5.00	--	--	7,100	2,240	7,100
1,2-Dichloropropane	µg/L	5.00	--	--	15	2,400	15
cis-1,3-Dichloropropene	µg/L	5.00	--	--	21	7.9	21
trans-1,3-Dichloropropene	µg/L	5.00	--	--	21	7.9	21
Ethylbenzene	µg/L	5.00	--	--	2,100	25	2,100
Methylene chloride	µg/L	5.00	--	--	590	2,560	590
1,1,2,2-Tetrachloroethane	µg/L	5.00	0.932	--	4	90.2	4
Tetrachloroethene	µg/L	5.00	0.825	--	3.3	45	3.3
Toluene	µg/L	5.00	--	--	15,000	215	15,000
1,1,1-Trichloroethane	µg/L	5.00	--	--	--	312	312
1,1,2-Trichloroethane	µg/L	5.00	--	--	16	550	16
Trichloroethene	µg/L	5.00	--	--	30	1,940	30
Trichlorofluoromethane	µg/L	5.00	--	--	--	--	--
Vinyl chloride	µg/L	5.00	1.29	--	2.4	930	2.4
PPL Polynuclear Aromatic Hydrocarbons (PAHs) – GC/MS-SIM- (SW846 8270C SIM)							
Acenaphthene	µg/L	0.200	--	--	990	6.6	990
Acenaphthylene	µg/L	0.200	--	--	--	-	--
Anthracene	µg/L	0.200	--	--	40,000	0.18	40,000
Benzo[a]anthracene	µg/L	0.200	0.0366	--	0.0018	0.02	0.0018
Benzo[b]fluoranthene	µg/L	0.200	--	--	--	-	--
Benzo[k]fluoranthene	µg/L	0.200	--	--	--	-	--
Benzo[a]pyrene	µg/L	0.200	0.0282	--	0.0018	0.02	0.0018
Benzo[ghi]perylene	µg/L	0.200	--	--	--	-	--
Chrysene	µg/L	0.200	--	--	--	-	--
Dibenzo[a,h]anthracene	µg/L	0.200	--	--	--	-	--
Fluoranthene	µg/L	0.200	--	--	140	1.6	140
Fluorene	µg/L	0.200	--	--	5,300	2.5	5,300
Indeno[1,2,3-cd]pyrene	µg/L	0.200	--	--	--	-	--

Parameter	Units	Laboratory Reporting Limit	Laboratory Method Detection Limit (a)	NRWQC Saltwater Aquatic Life CCC	NRWQC Human Health (Organism Only)	BTAG Value (c)	Screening Value (d)
Naphthalene	µg/L	0.200	--	--	--	1.4	1.4
Phenanthrene	µg/L	0.200	--	--	--	1.5	1.5
Pyrene	µg/L	0.200	--	--	4,000	0.24	4,000
Other PPL Semivolatile Organic Compounds – GC/MS (SW846 8270D Low Level)							
Benzidine	µg/L	20.0	4.74	--	0.00002	3.9	0.00002
Bis(2-chloroethyl)ether	µg/L	1.00	0.0317	--	0.53	--	0.53
Bis(2-chloroethoxy)methane	µg/L	1.00	--	--	--	--	--
2,2'-oxybis[1-chloropropane]	µg/L	1.00	--	--	--	--	--
Bis(2-ethylhexyl) phthalate	µg/L	2.00	--	--	2.2	16	2.2
4-Bromophenyl phenyl ether	µg/L	1.00	--	--	--	1.5	2
Butyl benzyl phthalate	µg/L	1.00	--	--	1,900	29.4	1,900
4-Chloro-3-methylphenol	µg/L	1.00	--	--	--	--	--
2-Chloronaphthalene	µg/L	0.200	--	--	1,600	--	1,600
2-Chlorophenol	µg/L	1.00	--	--	150	265	150
4-Chlorophenyl phenyl ether	µg/L	1.00	--	--	--	--	--
Di-n-butyl phthalate	µg/L	1.00	--	--	4,500	3.4	4,500
3,3'-Dichlorobenzidine	µg/L	1.00	0.147	--	0.028	73	0.028
2,4-Dichlorophenol	µg/L	1.00	--	--	290	11	290
Diethyl phthalate	µg/L	1.00	--	--	44,000	75.9	44,000
Dimethyl phthalate	µg/L	1.00	--	--	1,100,000	580	1,100,000
2,4-Dimethylphenol	µg/L	1.00	--	--	850	--	850
2,4-Dinitrophenol	µg/L	5.00	--	--	5,300	48.5	5,300
4,6-Dinitro-2-methylphenol	µg/L	5.00	--	--	280	--	280
2,4-Dinitrotoluene	µg/L	1.00	--	--	3.4	44	3.4
2,6-Dinitrotoluene	µg/L	1.00	--	--	--	81	81
Di-n-octyl phthalate	µg/L	1.00	--	--	--	22	22
1,2-Diphenylhydrazine	µg/L	1.00	--	--	--	--	--
Hexachlorobenzene	µg/L	1.00	0.0610	--	0.00029	0.0003	0.00029
Hexachlorobutadiene	µg/L	1.00	--	--	18	0.30	18
Hexachlorocyclopentadiene	µg/L	1.00	--	--	1,100	0.07	1,100
Hexachloroethane	µg/L	1.00	--	--	3.3	9.4	3.3
Isophorone	µg/L	1.00	--	--	960	129	960
Nitrobenzene	µg/L	2.00	--	--	690	66.8	690
N-Nitrosodimethylamine	µg/L	1.00	--	--	3	330,000	3
N-Nitrosodi-n-propylamine	µg/L	1.00	0.0501	--	0.51	--	0.51
N-Nitrosodiphenylamine	µg/L	1.00	--	--	6.0	120	6.0
2-Nitrophenol	µg/L	1.00	--	--	--	2,940	2,940
4-Nitrophenol	µg/L	5.00	--	--	--	71.7	71.7
Pentachlorophenol	µg/L	1.00	--	7.9	3.0	7.9	3.0
Phenol	µg/L	1.00	--	--	860,000	58	860,000
1,2,4-Trichlorobenzene	µg/L	1.00	--	--	70	5.4	70
2,4,6-Trichlorophenol	µg/L	1.00	--	--	2.4	61	2.4

Parameter	Units	Laboratory Reporting Limit	Laboratory Method Detection Limit (a)	NRWQC Saltwater Aquatic Life CCC	NRWQC Human Health (Organism Only)	BTAG Value (c)	Screening Value (d)
PPL Metals – ICP/MS (SW846 6020A)							
Antimony	µg/L	2.00	--	--	640	500	640
Arsenic	µg/L	1.00	--	36	0.14 (e)	12.5	36
Beryllium	µg/L	1.00	--	--	--	--	--
Cadmium	µg/L	1.00	--	8.8	--	0.12	8.8
Chromium	µg/L	2.00	--	50	--	57.5	50
Copper	µg/L	2.00	--	3.1	--	3.1	3.1
Lead	µg/L	1.00	--	8.1	--	8.1	8.1
Nickel	µg/L	1.00	--	8.2	4,600	8.2	8.2
Selenium	µg/L	5.00	--	71	4,200	71	71
Silver	µg/L	1.00	0.0362	--	--	0.23	0.23
Thallium	µg/L	1.00	0.0152	--	0.47	21.3	0.47
Zinc	µg/L	5.00	--	81	26,000	81	81
PPL Metals - Cold Vapor (SW846 7470A)							
Mercury	µg/L	0.200	0.0384	0.94	--	0.016	0.94
Total Cyanide (SW846 9014)							
Cyanide	µg/L	10.0	3.2	1	140	1	1

NOTES:

BTAG = EPA Region III Biological Technical Assistance Group

CCC = Criterion continuous (chronic) concentration

EPA = U.S. Environmental Protection Agency

NRWQC = EPA National Recommended Water Quality Criteria

PPL = Priority Pollutant List

(a) Method detection limits are shown only if RL is > Screening Value, and are required to be updated periodically and therefore subject to change.

(b) Target detection limit from the QA/QC Guidance Document (U.S. Environmental Protection Agency, April 1995).

(c) Surface water benchmarks from the EPA Region III Biological Technical Assistance Group (BTAG). Marine benchmarks are presented unless not available, in which case the freshwater benchmark is presented (except for metals).

(d) Screening value is NRWQC where available (and the lower of Aquatic Life or Human Health criteria if both are available); otherwise, BTAG.

(e) EPA is currently reassessing the human health criteria for arsenic; therefore, the current value is not used for screening.

Blue shading indicates the screening values which are less than the RL.

Attachment A

Well Integrity Evaluation Field Log

WELL INTEGRITY EVALUATION FIELD LOG

Well Designation:________________ Date:______________ Time:______________

Well Location:___________________ Technician:_________

Is a protective casing present	Yes	No
Are bollards present	Yes	No
Is there evidence of frost heave (leaning protective casing, broken concrete around base)?	Yes	No
Is a lock present and functioning	Yes	No
Is there a well identification tag or sign?	Yes	No
Upon opening the well, is the PVC riser centered in the well?	Yes	No
Is there an elevation measurement reference mark on the PVC riser?	Yes	No
Is the well straight?	Yes	No

Photo

Well Depth: ________________________

Latitude (WGS1984): ________________________

Longitude (WGS1984): ________________________

Comments:

____

____

____

____

Was photo taken? __________Photo taken facing:_____________________

HAS THE INTEGRITY OF THE WELL AFFECTED USABILITY:________________________

If so, summarize recommendations to re-establish well integrity:____________________________

____

____

Attachment B

Standard Operating Procedures

Standard Operating Procedure

For

Re-development of Existing Monitoring Wells

Prepared by
EA Engineering, Science, and Technology, Inc.
225 Schilling Circle, Suite 400
Hunt Valley, Maryland 21031

CONTENTS

1. SCOPE AND APPLICATION

Re-development of existing wells removes mobile particulates within the vicinity a monitoring well, and can decrease the turbidity of samples taken from the well. Development can also correct any damage to or clogging of the aquifer and increase the porosity of the aquifer in the vicinity of the well.

This standard operating procedure incorporates two well development techniques, over pumping and surging, in tandem. Over pumping is simply pumping the well at a rate higher than recharge. Surging is the operation of a plunger up and down within the well casing similar to a piston in a cylinder.

2. MATERIALS

The following equipment may be required:

- Well Development Form
- Boring Log and Well Completion Diagram for the well (if available)
- Submersible pump or bailer of appropriate capacity, and surge block
- Conductivity, pH, ORP, turbidity, dissolved oxygen, and temperature meter
- Electric well sounder and measuring tape
- Containers for purged water, if required.

3. PROCEDURE

Pump or bail the well to ensure that water flows into it, and to remove some of the fine materials from the well. Removal of a minimum of one equivalent volume is recommended at this point. The rate of removal should be high enough to stress the well by lowering the water level to approximately half its original level. If well recharge exceeds 15 gpm, the requirement to lower the head will be waived.

Slowly lower a close-fitting surge block into the well until it rests below the static water level, but above the screened interval. (NOTE: This latter is not required in the case of a light nonaqueous phase liquid well.)

Begin a gentle surging motion which will allow any material blocking the screen to break up, go into suspension, and move into the well. Continue surging for 5-10 minutes, remove surge block, and pump or bail the well, rapidly removing at least one equivalent volume.

Repeat previous step at successively lower levels within the well screen until the bottom of the well is reached. Note that development should always begin above, or at the top of, the screen and move progressively downward to prevent the surge block from becoming sand locked in the well casing. As development progresses, successive surging can be more vigorous and of longer duration as long as the amount of sediment in the screen is kept to a minimum.

Development is expected to take at least 2 hours in a small well installed in a clean sand, and may last several days in large wells, or in wells set in silts with low permeabilities.

Development will continue until little or no sediment can be pulled into the well, and target values for parameters listed below are met.

At a minimum, development will remove 3-5 well volumes of water. One development volume (DV) is defined as equivalent volume, plus the amount of fluid lost during drilling, plus the volume of water used in filter pack placement.

1. Monitor water quality parameters before beginning development procedures, and after removing 2, 2.5, and 3 well volumes of water.

2. If these parameters have stabilized over the three readings, the well will be considered developed.

3. If the parameters have not stabilized after these three readings, continue pumping the well to develop, but stop surging. Monitor the stabilization parameters every half DV.

4. When the parameters have stabilized over three consecutive readings at half DV intervals, the well will be considered developed.

All water removed must be disposed of as directed by the Work Plan.

Record all data as required on a Well Development Record Form (Appendix A). These data include:

- Depths and dimensions of the well, casing, and screen obtained from the well diagram (if available).

- Measurements of the following indicator parameters: turbidity, pH, conductivity, ORP, dissolved oxygen, and temperature.

- Target values for the indicator parameters listed above are as follows: pH – stabilize, conductivity – stabilize, ORP – stabilize, dissolved oxygen – stabilize, temperature – stabilize, turbidity – 5 nephelometric turbidity units or stabilize. A value is considered to have stabilized when three consecutive readings taken at half DV intervals are within 10 percent of each other.

- Notes on characteristics of the development water.

- Data on the equipment and technique used for development.

- Estimated recharge rate and rate/quantity of water removal during development.

4. MAINTENANCE

Not applicable.

5. PRECAUTIONS

Refer to the site-specific Health and Safety Plan for discussion of hazards and preventive measures during well development activities.

6. REFERENCES

Aller, L. et al. 1989. Handbook of Suggested Practices for the Design and Installation of Groundwater Monitoring Wells, National Water Well Association.

Appendix A

Field Record of Well Development Form

EA Engineering, P.C.
EA Science and Technology

FIELD RECORD OF WELL DEVELOPMENT

Project Name:	Project No:	Date:
EA Personnel:	Development Method:	
Weather/Temperature/Barometric Pressure:		Time:

Well No.:	Well Condition:
Well Diameter:	Measurement Reference:
Well Volume Calculations	
A. Depth To Water (ft):	D. Well Volume/ft:
B. Total Well Depth (ft):	E. Total Well Volume (gal)[C*D]:
C. Water Column Height (ft):	F. Five Well Volumes (gal):

Parameter	Beginning	1 Volume	2 Volumes	3 Volumes	4 Volumes	5 Volumes
Time (min)						
Depth to Water (ft)						
Purge Rate (gpm)						
Volume Purged (gal)						
pH						
Temperature (°F)						
Conductivity (µmhos/cm)						
Dissolved Oxygen						
Turbidity (NTU)						
ORP (mV)						
Parameter	**6 Volumes**	**7 Volumes**	**8 Volumes**	**9 Volumes**	**10 Volumes**	**End**
Time (min)						
Depth to Water (ft)						
Purge Rate (gpm)						
Volume Purged (gal)						
pH						
Temperature (°F)						
Conductivity (µmhos/cm)						
Dissolved Oxygen						
Turbidity (NTU)						
ORP (mV)						

NOTE: NTU = Nephelometric turbidity unit.
ORP = Oxidation-reduction potential.

COMMENTS AND OBSERVATIONS: ______________________________

EA Engineering, P.C.
EA Science and Technology

FIELD RECORD OF WELL DEVELOPMENT

Project Name:	Project No:	Date:
EA Personnel:	Development Method:	
Weather/Temperature/Barometric Pressure:		Time:

Well No.:	Well Condition:
Well Diameter:	Measurement Reference:

Parameter	Beginning	1 Volume	2 Volumes	3 Volumes	4 Volumes	5 Volumes
Time (min)						
Depth to Water (ft)						
Purge Rate (gpm)						
Volume Purged (gal)						
pH						
Temperature (°F)						
Conductivity (µmhos/cm)						
Dissolved Oxygen						
Turbidity (NTU)						
ORP (mV)						
Parameter	6 Volumes	7 Volumes	8 Volumes	9 Volumes	10 Volumes	End
Time (min)						
Depth to Water (ft)						
Purge Rate (gpm)						
Volume Purged (gal)						
pH						
Temperature (°F)						
Conductivity (µmhos/cm)						
Dissolved Oxygen						
Turbidity (NTU)						
ORP (mV)						

Standard Operating Procedure
for
Low-Flow Groundwater Sampling

Prepared by

EA Engineering, Science, and Technology, Inc.
225 Schilling Circle, Suite 400
Hunt Valley, Maryland 21031

Revision 0
June 2014

CONTENTS

1. SCOPE OF APPLICATION

The purpose of this standard operating procedure (SOP) is to establish the protocol for collecting groundwater samples using a low-flow pump. The procedure is designed to permit the collection of groundwater samples with minimum turbidity.

To obtain representative samples, subsurface disturbances should be kept to a minimum, thereby preventing sample alteration due to sampling actions. The reasoning behind the use of low-flow pumps to purge and sample monitoring wells is that these pumps minimize physical disturbance (turbulence) at the sampling point and chemical changes (aeration) in the medium. For these reasons, the low-flow pump is the preferred method for both purging and sampling in most cases. For the purposes of this SOP, “low-flow pumps” are variable speed submersible or peristaltic pumps.

Low-flow pumps may be used for purging and sampling any well having recharge greater than approximately 0.1 L/min, which is the practical lower limit of pump performance. Below that pumping rate, pump inefficiencies and/or overheating may alter the physical and chemical properties of the sample. If the pump is continuously operated at sampling rates higher than the well recharge rate, the water level will be lowered in the well, possibly allowing aeration of the sample which is unacceptable sampling procedure. Low-flow pumps are suitable for sampling wells with recharge rates lower than 0.1 L/min if precautions are taken to avoid aeration of the sample.

2. EQUIPMENT/MATERIALS

- Work Plan.
- Well construction data, location map, field data from last sampling event.
- Field logbook and Field Record of Well Gauging, Purging, and Sampling forms (Figure 1).
- Water level measuring device, 0.01 ft accuracy (electronic preferred) for monitoring water level drawdown during pumping operations.
- Variable speed, low-flow submersible or peristaltic pump.
- In-well tubing: Teflon or Teflon-lined polyethylene must be used to collect samples for organic analysis. For samples collected for inorganics analysis, Teflon or Teflon-lined polyethylene, PVC, Tygon, or polyethylene tubing may be used.
- Pump head tubing: Silicon tubing must be used to in the pump head assembly.
- Flow measurement supplies (e.g., graduated cylinder and stop watch).
- Power source (battery, etc.).

- Water quality indicator parameter monitoring instruments – pH, turbidity, specific conductance, temperature, oxidation-reduction potential, and dissolved oxygen.

- Flow-through cell (preferred) or clean container for water quality probe.

- Decontamination supplies (for monitoring instrumentation).

- Sample bottles and sample preservation supplies (as required by the analytical methods).

- Sample tags or labels.

- Cooler with bagged ice for sample bottles.

- Drum for purge water containment.

3. PRELIMINARY SITE ACTIVITIES

The following site activities are required prior to performing well purging and groundwater sampling. Field logbooks and sampling forms should be filled out as the procedure is being performed, as noted:

- Enter the following information in the field logbook and sampling form, as appropriate: site name, project number, field personnel, well identification, weather conditions, date and time, equipment used, and quality assurance/quality control data for field instrumentation.

- Check well for damage or evidence of tampering, record pertinent observations in field logbook and sampling form.

- Unlock well and remove well cap (if applicable).

- Measure and record the height of protective casing above the concrete pad, or ground surface, as appropriate. This reading is compared to that recorded during well installation as an indication of possible well damage or settling that may have occurred.

- If using a submersible pump: Lower the pump into the well, slowly so as not to agitate the water, until the pump is at the mid-point of the screened interval. Attach the pump's umbilical cord (which consists of power cord and sampling tubing) to the protective casing, or lock the cord spool so that the pump cannot move vertically during sampling.

- Lower the water level probe into the well. Measure and record the depth to water (to 0.01 ft) in the well to be sampled before purging begins. If the well casing does not have a reference point (usually a v-cut or indelible mark in the well casing), make one. If a reference point is made, it will be noted in the field logbook. Care should be taken to minimize disturbance of any particulate attached to the sides or at the bottom of the well. Leave the water level probe in place to monitor the water level during purging and sampling.

- If using a peristaltic pump: Position the intake of the sampling hose at the mid-point of the screened interval. Prepare the pump by checking electrical connections and discharge tubing. Locate the battery downwind of the well; connect the pump to the battery.

4. WELL PURGING AND SAMPLING PROCEDURES

The following general procedure should be followed to obtain representative groundwater samples. Field logbooks and sampling forms should be filled out as the procedure is being performed, as noted:

- Enter the following information in the field logbook and sampling form, as appropriate, prior to purging: purge date and time, purge method, and total well depth.

- Begin purging at the pump's lowest setting, then gradually increase rate until the pumping rate matches the aquifer recharge rate. If well diameter permits, establish that the water level has not dropped significantly such that the pump is dry (air in discharge) or tubing suction is broken. Ideally, the pump rate should cause little or no water level drawdown in the well (>0.5 ft and the water level should stabilize). The water level should be monitored every 3-5 minutes (or as appropriate) during pumping. Care should be taken not to cause pump suction to be broken, or entrainment of air in the pump system. Record pumping rate adjustments and depths to water. Pumping rates should, if needed, be reduced to the minimum capabilities of the pump to avoid pumping the well dry and/or to ensure stabilization of indicator parameters. If water levels continue to drop with the pump on the lowest flow rate, the pump will be shut off and the well will be allowed to recharge to prevent the well from going dry. **The well will not be purged to dryness prior to sampling to prevent erroneous field parameters and groundwater samples.** Sampling will commence as soon as the well has recharged to a sufficient level to collected the appropriate volume of samples with the pump.

- During purging of the well, monitor the field indicator parameters (turbidity, temperature, specific conductance, pH, oxidation-reduction potential, and dissolved oxygen) every 3-5 minutes (or as appropriate). Purging of the standing well water is considered complete when three consecutive readings of the water quality indicator parameters agree within approximately 10 percent. Turbidity readings consistently below 10 NTU are considered to represent stabilization of discharge water for this parameter. If the parameters have stabilized, but the turbidity is not in the range of the 10 NTU goal, the pump flow rate should be decreased and measurement of the parameters should continue every 3-5 minutes.

- Purge water at a well will be containerized if a well has exceeded applicable screening criteria in previous sampling events. Any purge water that is collected will be treated at the groundwater treatment plant.

- Prior to sampling, disconnect the sample discharge tubing from the flow-through cell. If the water discharged by the pump is silty, wait for the water to clear before sampling. Ensure that bubbles are not observed in the discharge tubing.

- Collect groundwater samples directly from the silicon tubing into preserved (when appropriate) sample containers. Begin filling sample containers from the pump discharge, allowing the water to fill the containers by allowing the pump discharge to flow gently down the inside of the container with as little agitation or aeration as possible. Collect the samples in the order below, as applicable:

  — Organic constituents (VOCs, then SVOCs)
  — Inorganics (metals, cyanide).

- VOC samples requiring pH adjustment will have their pH checked to assure that the proper pH has been obtained. This will require that a test sample be collected to determine the amount of preservative that needs to be added to the sample containers prior to sampling. Details on sample preservation are discussed in Section 5.

- Label each sample as collected and place into an ice cooler for delivery to the laboratory.

- After collection of the samples, restore the dedicated tubing assembly to the well by hanging the tube inside the well by the specially-designed PVC well cap assembly. Lock well.

- Complete remaining portions of Field Record of Well Gauging, Purging, and Sampling form (Figure 1) after each well is sampled, including: sample date and time, total quantity of water removed, well sampling sequence, types of sample bottles used, sample identification numbers, preservatives used, parameters requested for analysis, and field observations of sampling event.

- The tubing used for purging and sampling will be changed after use at each well.

5. SAMPLE PRESERVATION

The following preservation procedures are examples of typical preservation protocols specific to the indicated analyses. Pre-preserved bottles will be used if possible. Minimum sample preservation requirements for each parameter group are summarized below:

- **VOCs—**Aqueous VOC samples must be collected as specified below. Each VOC sample is taken in duplicate:

  — Uncap the sample bottle, taking care not to touch the Teflon-faced septum. If the septum is contaminated in any way, it should be replaced.

  — Fill a sample bottle, preserve with HCL, and check the pH. Adjust the volume of HCL to assure pH<2.

  — Add the amount of HCL determined in the above step, and fill the sample vial slowly from the tubing, minimizing air entrainment, until the vial slightly overflows.

- Place the Teflon-faced silicon rubber septum on the convex meniscus, Teflon side (shiny side) down, and screw cap on.
- Invert the bottle, tap lightly, and check for air bubbles.
- If air bubbles are present, open the bottle, add sample to eliminate air bubbles, and reseal. Repeat this procedure until the bottle is filled and no air bubbles are detected.
- Place samples on ice until shipment.

- **SVOCs**—Fill the sample bottle, seal container, and place sample on ice for shipment.
- **Inorganics**—Fill the sample bottle, preserve the sample to pH<2 with nitric acid (HNO_3), seal container, and place sample on ice for shipment.

Disposable pipettes should be used to introduce chemicals into the samples if necessary. Chemicals used for preserving should be poured into a 150-ml beaker. They should not be drawn directly from the preservative bottles because the bottle may become contaminated. Measurements for pH and temperature should not be taken from the sample containers. When preserving samples to a required pH, pH paper should be used to check the resultant pH. The sample should be poured across the pH paper. Never place pH paper directly into sample.

NOTE: Shipping regulations limit the amount of preservative which can be added. For a 1-L sample, this is generally 1.5 ml of acid preservative.

6. FIELD QUALITY CONTROL

Quality control samples are required to verify that the sample collection and handling process has not affected the quality of the groundwater samples. All field quality control samples must be prepared exactly as regular investigation samples with regard to sample volume, containers, and preservation. The following quality control samples will be collected for each SDG (an SDG may not exceed 20 samples) at the frequency noted:

- Field Duplicate—Required at a frequency of 10 percent per SDG
- Matrix Spike/Matrix Spike Duplicate—Required at a frequency of 5 percent
- Equipment (Rinsate) Blank—Required once prior to installation of dedicated sample tubing
- Source Water Blank—Required at a frequency of one per source per sampling event
- Trip Blank—Required for VOC samples at a frequency of one per sample shipment.
- Temperature Blank—Required at a frequency of once per sample shipment container.

7. DECONTAMINATION

Non-dedicated sampling and field monitoring equipment will be decontaminated prior to use and following sampling of each well. This equipment will be decontaminated by the procedure listed below. Alternate procedures must be approved by the Project Manager prior to the sampling event. Decontamination fluids will be collected in a 5-gal bucket and treated at the groundwater treatment plant.

The following decontamination procedure will be used:

- Flush the equipment with potable water
- Flush with non-phosphate detergent solution
- Flush with tap water to remove all of the detergent solution
- Flush with distilled/deionized water
- Flush with isopropyl alcohol
- Flush with distilled/deionized water.

It is recommended that the detergent and isopropyl alcohol used in the above sequence be used sparingly.

2. REFERENCES

U.S. Environmental Protection Agency. 1996. Groundwater Issue-Low Flow Sampling (Minimal Drawdown) Groundwater Sampling Procedures. April.

FIELD RECORD OF WELL GAUGING, PURGING, AND SAMPLING

Site Name:		Project Number:	
Well ID:		Well Lock Status:	
Well Condition:		Weather:	

Gauge Date:		Gauge Time:	
Sounding Method:		Measurement Ref:	
Stick Up/Down (ft):		Well Diameter (in.):	

Purge Date:		Purge Time:	
Purge Method:		Field Personnel:	
Ambient Air VOCs (ppm):		Well Mouth VOCs (ppm):	

WELL VOLUME

A. Well Depth (ft):		D. Well Volume/ft (L):	
B. Depth to Water (ft):		E. Well Volume (L) (C*D):	
C. Liquid Depth (ft) (A-B)		F. Three Well Volumes (L) (E*3):	

G. Measurable LNAPL? Yes ________ /ft No ________

Parameter	Beginning	1	2	3	4	5
Time (min.)						
Depth to Water (ft)						
Purge Rate (L/min)						
Volume Purged (L)						
pH						
Temperature (°C)						
Conductivity (μmhos/cm)						
Dissolved Oxygen (mg/L)						
Turbidity (NTU)						
eH (mV)						

Total Quantity of Water Removed (L): ________________

Samplers:		Sampling Time (Start/End):	
Sampling Date:		Decontamination Fluids Used:	
Sample Type:		Sample Preservatives:	

Sample Bottle IDs: ________________

Sample Parameters: ________________

Figure 1.

FIELD RECORD OF WELL GAUGING, PURGING, AND SAMPLING

Site Name:	Project Number:	Date:
Well ID:	Field Personnel:	

Parameter	6	7	8	9	10	11
Time (min.)						
Depth to Water (ft)						
Purge Rate (L/min)						
Volume Purged (L)						
pH						
Temperature (°C)						
Conductivity (μmhos/cm)						
Dissolved Oxygen (mg/L)						
Turbidity (NTU)						
eH (mV)						

Parameter	12	13	14	15	16	17
Time (min.)						
Depth to Water (ft)						
Purge Rate (L/min)						
Volume Purged (L)						
pH						
Temperature (°C)						
Conductivity (μmhos/cm)						
Dissolved Oxygen (mg/L)						
Turbidity (NTU)						
eH (mV)						

Comments and Observations:

Figure 1.